International Archive of Applied Sciences and Technology
Int. Arch. App. Sci. Technol; Vol 6 [1]March 2015: 01- 03

[ISO9001: 2008 Certified Organization]
www.soeagra.co/iaast.html

IAAST
ONLINE ISSN 2277- 1565
PRINT ISSN 0976 - 4828

CODEN: IAASCA **REVIEW ARTICLE**

Novel Carbon Nanotubes and Synthesis Methods

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ABSTRACT

Carbon nanotubes are interesting nano structures with large application potential. Carbon nanotubes are of both fundamental and technological interest. Carbon nanotubes have continuously attracted due to their unique physical, mechanical, chemical, thermal and electronic properties. Researchers have developed various kinds of carbon nanotubes with the help of different preparation methods. Mostly methods used metal catalyst for the good yield of carbon nanotubes. Some methods are commercially viable and some are not. In this paper I have given some points about various preparation methods of carbon nanotubes. There are many methods to grow carbon nanotubes but among them arc discharge method, laser ablation method and chemical vapour deposition method are popular methods. The deposition of carbon nano tubes on planar substrates is prominent but some work is reported on the deposition of non planar surfaces also. Laser ablation method is a promising method for producing different variety of carbon nano tubes. In chemical vapour deposition the decomposition of the carbon precursor and carbon nano tube formation take place on the surface of catalyst. In this method carbon source is in gas phase.

Key Words*: Single walled carbon nanotubes (SWNTs),Multi walled nanotubes(MWNTs),Arc discharge, laser ablation, Chemical vapour deposition (CVD) etc .*

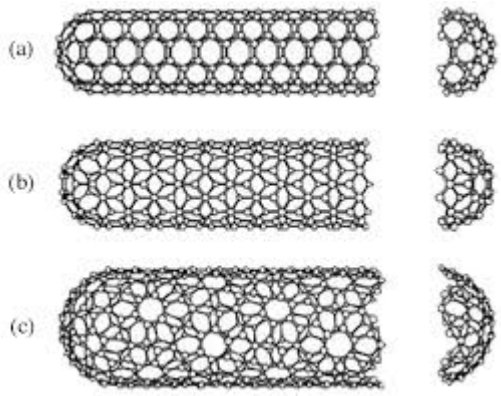
Received 02/01/2015 **Revised 12/02/2015** **Accepted 03/03/2015**

Ciation of this article

Pratima S. Novel Carbon Nanotubes and Synthesis Methods. Int. Arch. App. Sci. Technol; Vol 6 [1] March 2015: 01-09. DOI.10.15515/iaast.0976-4828.6.1.13

INTRODUCTION

Carbon nanotubes may be of various structures and each structure has different properties. The carbon nanotubes referred as armchair, zigzag and chiral structures(as shown in figure given below)depending upon the way of rolling the graphite sheet to make it tube . The carbon nanotubes are nano cylinders with each end attached to half of fullerene like structure. The unique properties of CNTs include extremely high tensile strength, flexibility, light weight, high electrical conductivity and high thermal conductivity. They may be conducting or semiconducting depending upon the structure of carbon nanotubes. CNTs can be mainly classified in two types: single walled carbon nanotubes (SWCNTs) and multiwalled carbon nanotubes (MWCNTs). Both have different properties. SWCNTs can be considered as seamless cylinder of single grapheme sheet. SWCNTs were prepared [1].MWCNTs can be considered as coaxial cylinders of single walled carbon nanotubes. The spacing between two layers of nanotubes has been reported .34 nm and their diameter vary from 10nm to 100nm are two main models for MWCNTs.The Russian doll model and the Swiss roll model are two models for multi walled carbon nanotubes. Carbon nanocoil, carbon nanofiber, carbon nanocone, carbon nanohorn, carbon nanoribbon are other varieties of carbon nanotubes. Carbon nanotubes have unique properties. Carbon nanotubes are of both fundamental and technological interest. Carbon nanotubes are unique tubular structures of nanometer diameter and large ratio of length and diameter. Nanotubes can be metallic or semiconducting depending on their structural parameters. Because of this carbon nanotubes have broad applications in electronic devices including field- effect transistors, single- electron transistors and rectifying diodes .The purpose of the present review is to give brief account of the carbon nanotubes research and development as well as their applications.



Preparation method of carbon nanotubes: There are many reported preparation methods for carbon nanotubes.Among them some important methods are discussed below.

Arc Discharge Method: Existence of carbon nanotubes was noticed during the preparation of C_{60} fullerene molecules by the arc discharge method [2] . The main parts of arc discharge method are a vacuum chamber, a furnace , graphite electrodes, a water cooled trap and high voltage power supply .With the help of two graphite rods current arc discharge is performed.This process is performed in the pure inert gas atmosphere and current range from 50 A to 100 A. It depends on the diameter of rods, their separation and the gas pressure . During arc discharge process sublimation of carbon takes palace.Multi walled carbon nanotubes and impurities deposite on the cathode. In 1993 the CNT is synthesized by arc dischargr method[3]. Good results depend on appropriate experimental parameter such as pressure, nature of gas, temperature, catalyst etc. Diameter of CNT depends upon the temperature directly. High yield of MWCNTs occurred when helium gas in reactor is replaced by hydrogen [4] . The temperature, carbon and metal catalyst affect the diameter distribution of carbon nanotubes. Arc discharge method is proposed for the synthesis of multiwalled carbon nanotubes in liquid nitrogen [5].

Laser ablation method :

In this method in an inert atmosphere and under high temperature, graphite rod is vaporized by laser beam. Size and diameter of carbon nanotubes vary with the variation of laser, catalyst composition, temperature, nature and pressure of the gases etc. Different laser give different result.Both SWCNTs and MWCNTs can be prepared by this method. SWCNTs can be produced by the laser ablation method[6].At higher temperature laser ablation method is good for high yield of SWCNTs. Bi metal mixture arises as one of the most efficient catalyst [7].

Chemical vapour deposition:

In this technique decomposition of the carbon precursor causes CNT growth on the surface of the catalyst particles. There are many CVD methods for the synthesis. In thermal chemical vapour deosition method an energy source is used to impart energy to carbon molecules of carbon source in gas phase. The decomposed reactive radical species diffuse down to the substrate and coated on the surface of the catalyst (Ni, Fe, or Co) . Common carbon sources are methane, carbon monoxide, acetylene etc. Under controlled condition the production of CNTs take place. In this method the first step is to prepare catalyst and then second step is heating up the substrate in carbon rich gaseous atmosphere. Temperature ranges from 400 ^{0} C to1000 ^{0} C. Good quality and greater yield of CNTs is controlled by the temperature. [8}. Higher temperature is suitable for good results[9].Different carbon soures give different results .Carbon monoxide supports for production of SWCNTs while acetylene for MWCNTs.In Plasma enhanced chemical vapour deposition method production of CNTs takes place at lower temperature.Electrical energy is used the produce plasma and high energy electrons in plasma decompose the hydrocarbon molecules. vertically aligned CNTs have been reported using plasma enhanced chemical vapor deposition method [10].Generally the plasma sources use radio frequency for growing CNTs .In laser assisted chemical vapour deposition method different types of laser are suitable for CNT synthesis. CNTs have been produced by using Co_2 laser and $Fe(Co)_5$ catalysts [11].In catalytic chemical vapour deposition method the pyrolysis of hydrocarbons source over the transition metals (Fe, Co, Ni) in the temperature range 500^{0}c to 1000^{o}c takes place. The High Pressure Carbon Mono oxide (Hi PCO) method is used to produce carbon nanotube on large scale .

Carbon nanotubes can also be synthesized by flame synthesis technique [12].When carbon nanotubes are produced the result is a mixture of different kinds of impurities as some metallic, some conducting and various impurities like carbon nano particles amorphous carbon fullerenes etc. These impurities affect

the properties of carbon nanotubes. Thus many methods are used to purify the carbon nanotubes and make them suitable for applications

CONCLUSIONS

In all preparation methods each one provide energy to carbon source to create carbon atom and grow carbon nanotubes.Chemical vapour depositions, laser cable action and discharge methods are most popular methods.Chemical vapour deposition method is used for large scale production of carbon nanotubes.Laser ablation method and are discharge methods are very expensive and produce carbon nanotubes with large impurities.Chemical vapour deposition method is the best method to generate carbon nanotubes as it can take place at low temperature and size of carbon nanotubes can be controlled by varying the size of catalyst particles. It is interesting to compare the different methods for preparation of carbon nanotubes.

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